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TITLE: OPTICAL DEVICE, OPTICAL SYSTEM, METHOD OF PRODUCTION OF SAME, AND MOLD FOR PRODUCTION OF SAME

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SIR;

CERTIFIED TRANSLATION

I, Takahisa SATOH, am an official translator of the Japanese language into the English language and I hereby certify that the attached comprises an accurate translation into English of Japanese Application No. 2000-246934, filed on August 16, 2000.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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[TITLE OF THE INVENTION] Optical Device, Method of Production of Optical Device, and Metallic mold for production of optical device

[CLAIMS]

[Claim 1]

An optical device obtained by forming a concavity by a pin in optical material in a molten state or softened state, hardening the optical material with the related concavity formed therein, and polishing or grinding a face where the concavity is formed so that a hole of a front end of the concavity remains in a base material obtained thereby.

[Claim 2]

An optical device as set forth in claim 1, wherein the hole of the front end of the concavity has a spherical or substantially spherical shape.

[Claim 3]

An optical device as set forth in claim 1, wherein

the hardened optical material has first and second faces facing each other,

the concavity is formed in the first face, the area around the concavity is flat, and

the area around of th concavity in the first face and the second face are parallel or substantially

parallel to each other.

[Claim 4]

An optical device as set forth in claim 1, wherein an optical material having a different refractive index from that of the base material is filled in the concavity.

[Claim 5]

A metallic mold for production of an optical device made of an optical material, having

a cavity into which an optical material in a molten state or softened state is filled and

a pin for forming a concavity in the optical material in the molten state or softened state in the cavity, wherein

the pin projects out into the cavity while penetrating through a wall of the cavity from the outside.

[Claim 6]

A metallic mold for production of an optical device as set forth in claim 5, wherein the hole of the front end of the concavity has a spherical or substantially spherical shape.

[Claim 7]

A metallic mold for production of an optical d vic as set forth in claim 5, wh rein

the pin has a head and a projection proj cting out from the head, and

the projection has

a rounded projecting front end,

a pole having a constant diameter, and

a taper located between the front end and the pole and having a shape flaring from the front end to the pole.

[Claim 8]

A metallic mold for production of an optical device as set forth in claim 5, wherein

the area around of the pin in the wall of the cavity is flat, and

the surface of the facing wall facing to the wall of the related cavity is flat.

[Claim 9]

A method for producing an optical device by using a metallic mold having a cavity into which an optical material in a molten state or softened state is to be filled and a pin for forming a concavity in the optical material in the molten state or softened state in the cavity, wherein the pin penetrates through the wall of the cavity from the outside and projects out into th cavity, having

a step of filling the ptical material in the molten

state or soft ned state in the cavity to create a base material formed with the concavity by a simple molding and

a step of polishing or grinding the face of the base material where the concavity is formed so that a hole of a front end of the concavity remains.

[Claim 10]

A method of production of an optical device as set forth in claim 9, wherein the hole of the front end of the concavity has a spherical or substantially spherical shape.

[Claim 11]

A method for producing an optical device by using a metallic mold having a cavity into which an optical material in a molten state or softened state is to be filled and a pin for forming a concavity in the optical material in the molten state or softened state in the cavity, wherein the pin penetrates through the wall of the cavity from the outside and projects out into the cavity, having

a step of filling the optical material in the molten state or softened state in the cavity to create a base material form d with the concavity by simple molding,

a step of filling an optical material having a different refractive index from that f the base material

in the concavity of th base material, and

a step of flattening the surface of the optical material filled in the concavity to form a convex lens made of the related optical material.

[Claim 12]

A method of production of an optical device as set forth in claim 11, further having a step of polishing or grinding the face of the base material where the concavity is formed so that a hole of the front end of the concavity filled with the optical material having a different refractive index remains.

[Claim 13]

A method of production of an optical device as set forth in claim 11, wherein the hole of the front end of the concavity has a spherical or substantially spherical shape.

[Claim 14]

A method of production of an optical device having

a step of forming a concavity by a pin in an optical material in a molten state or softened state and

a step of polishing or grinding the face where the concavity is formed so that a hole of a front end of the concavity remains in a base material obtained by hardening the optical material form d with the related concavity.

[Claim 15]

A method of production of an optical device as set forth in claim 14, wherein the hole of the front end of the concavity has a spherical or substantially spherical shape.

[Claim 16]

A method of production of an optical device as set forth in claim 14, wherein the front end of the pin has a rounded projecting shape.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field of the Invention]

The present invention relates to an optical device, a method of production of an optical device, and a metallic mold for production of an optical device.

[0002]

[Prior Art]

The conventional methods of production of an optical device include for example the method of production of an optical device by filling an optical material such as molten glass into a metallic mold formed with a cavity of a desired lens shape to produce a mold lens.

Also, there is a method of production of an optical device by utilizing an tching m thod such as a r active ion etching (RIE) to etch an optical material into th

desired lens shape using a photoresist as an etching mask.

Also, there is a method of production of an optical device by mechanically polishing an optical material to a desired lens shape.

[0003]

[Problem to be Solved by the Invention]

In the conventional method of production of an optical device, for example, the method of production of an optical device by simple molding, it is difficult to obtain a lens having a large numerical aperture (NA) and a small diameter and it is difficult to reduce the lens diameter to 1 mm or less.

Also, in the method of production of an optical device using an etching technique such as RIE, there is a problem in that there are restrictions on the optical material and there are a few optical materials of high refractive indexes capable of obtaining lenses having large numerical apertures among the optical materials capable of RIE and other etching.

[0004]

From the viewpoint of the increase of capacity of optical discs, an increase of the num rical apertur NA of an object l ns of an optical disc drive is d manded. Als , from the viewpoint of the reducti n f size of the

optical disc drive and/or optical pick-up, a reduction of size of the lens is demanded.

[0005]

An object of the present invention is to provide a method of production of an optical device capable of producing an optical device having a small sized lens, a metallic mold for production of an optical device useable in this method of production of an optical device, and an optical device which can be obtained by the related method of production of an optical device.

[0006]

[Means for Solving the Problem]

An optical device according to the present invention is configured by forming a concavity by a pin in optical material in a molten state or softened state, hardening the optical material with the related concavity formed therein, and polishing or grinding a face where the concavity is formed so that a hole of a front end of the concavity remains in a base material obtained thereby.

[0007]

In the optical device according to the present invention, preferably the hole of the front end of the c ncavity has a spherical or substantially spherical shape.

[0008]

In the optical device acc rding to the present invention, preferably the hardened optical material has first and second faces facing each other, the concavity is formed in the first face, the area around the concavity is flat, and the area around of the concavity in the first face and the second face are parallel or substantially parallel to each other.

[0009]

In the optical device according to the present invention, preferably an optical material having a different refractive index from that of the base material is filled in the concavity.

[0010]

A metallic mold for production of an optical device according to the present invention is a metallic mold for production of an optical device made of an optical material, having a cavity into which an optical material in a molten state or softened state is filled and a pin for forming a concavity in the optical material in the molten state or softened state in the cavity, wherein the pin projects out into the cavity while penetrating through a wall of the cavity from the outside.

[0011]

In the metallic mold for production of an optical device according to the present inv ntion, pref rably the

hole of the front end of the concavity has the sph rical or substantially spherical shape.

[0012]

In the metallic mold for production of an optical device according to the present invention, preferably the pin has a head and a projection projecting out from the head, and the projection has a rounded projecting front end, a pole having a constant diameter, and a taper located between the front end and the pole and having a shape flaring from the front end to the pole.

[0013]

In the metallic mold for production of an optical device according to the present invention, preferably the area around of the pin in the wall of the cavity is flat, and the surface of the facing wall facing to the wall of the related cavity is flat.

[0014]

A first method of production of an optical device according to the present invention is a production method for producing an optical device by using a metallic mold having a cavity into which an optical material in a molten state or softened state is to be filled and a pin for forming a concavity in th optical material in th m lten state or softened state in the cavity, wherein the pin penetrates through the wall of the cavity from the

outside and projects out int th cavity, having a step of filling the optical material in the molten state or softened state in the cavity to create a base material formed with the concavity by a simple molding and a step of polishing or grinding the face of the base material where the concavity is formed so that a hole of a front end of the concavity remains.

[0015]

In the first method of production of an optical device according to the present invention, preferably the hole of the front end of the concavity has a spherical or substantially spherical shape.

[0016]

A second method of production of an optical device according to the present invention is a production method for producing an optical device by using a metallic mold having a cavity into which an optical material in a molten state or softened state is to be filled and a pin for forming a concavity in the optical material in the molten state or softened state in the cavity, wherein the pin penetrates through the wall of the cavity from the outside and projects out into the cavity, having a step of filling the optical material in the molten state or soften d state in the cavity to create a base material formed with the concavity by simple molding, a step of

filling an optical material having a different refractive index from that of the base material in the concavity of the base material, and a step of flattening the surface of the optical material filled in the concavity to form a convex lens made of the related optical material.

[0017]

The second method of production of an optical device according to the present invention preferably further has a step of polishing or grinding the face of the base material where the concavity is formed so that a hole of the front end of the concavity filled with the optical material having a different refractive index remains.

[0018]

In the second method of production of an optical device according to the present invention, preferably the hole of the front end of the concavity has a spherical or substantially spherical shape.

[0019]

A third method of production of an optical device according to the present invention has a step of forming a concavity by a pin in an optical material in a molten state or softened state and a step of polishing or grinding the face where the concavity is formed so that a hole of a front end of the concavity remains in a base material obtained by hardening the optical material

formed with the related concavity.

[0020]

In the third method of production of an optical device according to the present invention, preferably the hole of the front end of the concavity has a spherical or substantially spherical shape.

[0021]

In the third method of production of an optical device according to the present invention, preferably the front end of the pin has a rounded projecting shape.

[0022]

In the first method of production of an optical device according to the present invention, the optical device is produced by using a metallic mold. The production use metallic mold has a cavity into which the optical material in the molten state or softened state is to be filled and a pin forming a concavity in the optical material in the molten state or softened state in this cavity. This pin penetrates through the wall of the cavity from the outside and projects out into the cavity.

By filling an optical material in the molten state or softened state in the cavity to mold a base material form d with the concavity and polishing or grinding th face f the base material where the concavity is formed so that the hole of the front nd of the concavity

remains, an optical device having a lens comprised of the hole of the front end of the concavity formed in the base material can be produced and it is possible to produce an optical device having a small sized lens.

[0023]

In the second method of production of an optical device according to the present invention, the optical device is produced by using the metallic mold. The production use metallic mold has a cavity into which the optical material in the molten state or softened state is filled and a pin forming a concavity in the optical material in the molten state or softened state in this cavity. This pin penetrates through the wall of the cavity from the outside and projects out into the cavity.

By filling an optical material in the molten state or softened state in the cavity to mold a base material formed with the concavity and filling an optical material having a different refractive index from that of the base material in the concavity of the base material, an optical device having a different refractive index can be formed close to the surface of the concavity of the base material.

By flattening the surfac of the optical material filled in the concavity of the bas material to form a convex lens made f the r lated optical material, an

optical device made of the optical material filled in the concavity of the base material can be produced and it is possible to produce an optical device having a small sized lens.

[0024]

The third method of production of an optical device according to the present invention comprises forming a concavity by a pin in an optical material in the molten state or softened state and polishing or grinding the face where the concavity is formed so that a hole of the front end of the concavity remains in a base material obtained by hardening the optical material formed with the concavity. By polishing or grinding in this way, an optical device having a lens comprised of the hole of the front end of the concavity formed in the base material can be produced and it is possible to produce an optical device having a small sized lens.

[0025]

[Embodiments of the Invention]

Below, an explanation will be made of embodiments of the present invention by referring to the attached drawings.

[0026]

Figure 1 is a sch matic view of th configuration of an mbodiment of a metallic mold for production of an

optical device according to the present invention.

[0027]

This production use metallic mold (metallic mold) 9 of an optical device is formed with a passageway 2 for passing an optical material in the molten state or softened state and with a cavity 1. Also, in the cavity 1 of the metallic mold 9, parts of projections 4A and 5A of metallic mold pins 4 and 5 project out from a bottom face 1B of the cavity 1. The bottom face 1B of the cavity 1 is flat, and areas around the projections 4A and 5A in the bottom face 1B are flat. Also, an upper wall (upper face) of the cavity 1 is flat.

[0028]

The metallic mold pins 4 and 5 have heads 4H and 5H of flat shapes and projections 4A and 5A projecting out from the heads 4H and 5H in a vertical direction. The metallic mold pins 4 and 5 have identical shapes.

The heads 4H and 5H of the metallic mold pins 4 and 5 closely contact the bottom face of the metallic mold 9, and the projections 4A and 5A of the metallic mold pins 4 and 5 partially project out into the cavity 1 while penetrating through holes 94 and 95 provided in a bottom wall of the metallic mold 9.

[0029]

Figure 2 is a schematic enlarg d view f part of the

projection 5A of the metallic mold pin 5. The projection 5A has a front end 5M, a taper 5T, and a pole 5P. The projection 5A has a rotationally symmetric shape about an axis 5Z. The axis 5Z is vertical to the head 5H of the metallic mold pin 5 (or a bottom plane thereof).

[0030]

The boundary between the front end 5M and the taper 5T forms a circle having a radius of (1a)/2 from the rotational symmetry axis 5Z. The front end 5M is a region providing the lens shape (or a region imparting a lens function) and has a rounded projecting shape.

The taper 5T is located between the front end 5M and the pole 5P. The surface thereof forms a tapered face flaring out from the front end 5M in the direction of the pole 5P.

The pole 5P has a constant diameter (1a + 1b x 2). The pole 5P and the taper 5T are regions outside the region providing the lens shape.

[0031]

Figure 3 is an explanatory view of a molded article produced by the production use metallic mold 9 of an optical device of Fig. 1.

An optical material in the molten state or soften d state is filled in the cavity 1 of the metallic mold 9 of Fig. 1, this ptical material is hardened, the m tallic

mold 9 is opened, and th mold d article is tak n out. Then, the portion corresponding to the passageway 2 is removed from the molded article to obtain a molded article 11 as shown in Fig. 3. Alternatively, by filling the optical material in the molten state or softened state, then removing the portion corresponding to the passageway 2 from the filled optical material in the molten state or softened state and hardening the same, opening the metallic mold 9, and taking out the molded article, a molded article 11 as shown in Fig. 3 can be obtained.

Note that the optical material to be injected into the cavity 1 may be for example quartz, glass, plastic, or a synthetic resin in the molten state.

[0032]

The bottom face 11B of the molded article 11 is formed with concavities 14A and 15A of shapes transferred from the projections 4A and 5A of the metallic mold pins 4 and 5. The areas around the concavities 14A and 15A are flat. An upper side base material 12A in the base material 12 comprising the molded article 11 is located at an upper side of a boundary 12C, and a lower side base material 12B is located at a lower side f the boundary 12C.

The base material 12B on the lower side of the

molded article 11 has the shap s of the poles 4P and 5P and tapers 4T and 5T of the metallic mold pins 4 and 5 transferred to it.

The base material 12A on the upper side of the molded article 11 has the shapes of the front ends 4M and 5M of the metallic mold pins 4 and 5 transferred to it.

[0033]

Figure 4 is an enlarged view of the concavity 15A of the molded article 11 of Fig. 3 and the area around it. The concavity 15A has a rotationally symmetric shape about an axis 15Z.

The base material 12B at the lower side of the molded article 11 is formed with a hole 15P having a constant diameter (1a + 1b x 2) of the shape of the pole 5P of the metallic mold pin 5 transferred to it and with a hole 15T of the shape of the taper 5T transferred to it and having a diameter decreasing in a depth direction by a constant rate. The (inner walls of) holes 15P and 15T of the lower side base material 12B are regions not having or substantially not having a lens function.

[0034]

The upper side base material 12A of the molded article 11 is formed with a spherical or substantially spherical hole 15M of the shap of the front end 5M of the metallic mold pin 5 transferred to it and of a radius

of curvature which is constant or substantially constant. The (inner wall of) hole 15M of this upper side base material 12A is a region having the lens function. The maximum diameter of the hole 15M is 1a.

[0035]

Figure 5 is a schematic view of the configuration of an optical device.

This optical device 17 is comprised of the upper side base material 12A of the molded article 11 of Fig. 4. By removing the lower side base material 12B from the molded article 11 by for example polishing or grinding, the upper side base material 12A can be obtained and the optical device 17 can be produced. The bottom face of the optical device 17 is formed with holes 14M and 15M of the front ends of the concavities 14A and 15A. The flat portion of the bottom face of the optical device 17 coincides with the boundary 12C.

[0036]

Figure 6 is an enlarged view of the hole 15M of Fig. 5 and the area around it. The hole 15M has a rotationally symmetric shape about the axis 15Z and forms a concave lens.

By using the metallic mold 9 in this way, it is possible t form an optical device 17 having a hole 15M having a small radius or diameter and having a lens

function.

[0037]

Figure 7 is an explanatory view of a molded article 11K in a state where a layer 18 of an optical material 18G is laminated on the bottom face 11B of the molded article 11 of Fig. 3. Figure 8 is an enlarged view of the concavity 15A in Fig. 7 and the area around it. The optical material of the molded article 11 and the optical material 18G of the layer 18 have different refractive indexes.

The layer 18 of the optical material 18G is laminated on the bottom face 11B by the technique of for example sputtering, vapor deposition, or ion implantation. By laminating the layer 18, the optical material 18G can be filled in the concavities 14A and 15A or holes 14M and 15M of the molded article 11.

The bottom face 18B of the layer 18 is formed with concavities 184 and 185 corresponding to the concavities 14A and 15A.

[0038]

Figure 9 is an explanatory view of an optical device produced from the molded article 11K of Fig. 7.

In this optical device 11K', a bottom face 18B of th molded article 11K f Fig. 7 and the lower side base mat rial 12B are polished and the polished face (lens

bottom fac) is flattened.

At the bottom face of the optical device 11K, a lower side base material 12B' and the optical material 18G filled in the holes 14A' and 15A' are exposed. The bottom face of the optical device 11K' is parallel to the upper face.

Note that the base material 12B on the lower side of the molded article 11K is polished to form the lower side base material 12B'. Along with this, the holes 14A and 15A become the holes 14A' and 15A'.

[0039]

Figure 10 is an enlarged view of the hole 15A in Fig. 9 and the area around it.

The optical device 11K is formed with a hole 15P' having a constant diameter, a hole 15T having a diameter which becomes proportionally smaller in accordance with a distance from the hole 15P' in the depth direction, and a hole 15M of a spherical or substantially spherical shape. The holes 15P', 15T, and 15M are filled with the optical material 18G. The optical material filled in the hole 15M forms the convex lens. The hole 15P' becomes shorter in length in the depth direction than the hole 15P by the p lishing of the layer 18 and the base mat rial 12B.

[0040]

In the optical device 11K of Fig. 10, the hole 15P'

of the constant diam ter remains, but the bottom face of the optical device 11K may be further polished so as to remove the hole 15P' of the constant diameter. In this case, the polishing is carried out so that the polished face becomes parallel to the boundary 12C.

Figure 11 is a view of the configuration of an optical device 11K" formed by polishing the bottom face of the optical device 11K' of Fig. 9 and Fig. 10. In this optical device 11K", the bottom face of the optical device 11K' is polished to remove the hole 15P'. Note that the base material 12B at the lower side of the optical device 11K' is polished to form a lower side base material 12B".

[0041]

In the lens 11K" of Fig. 11, the hole 15T remains, but the bottom face of the optical device 11K" may be further polished so as to remove the hole 15T. In this case, the polishing is carried out so that the polished face becomes parallel to the boundary 12C.

Figure 12 is a view of the configuration of an optical device 11N obtained by polishing the bottom face of the optical device 11K" of Fig. 11. Figure 13 is an enlarged vi w of the hole 15M in Fig. 12.

In this optical d vice 11N, the lower sid base mat rial 12B" is removed from the optical device 11K" by

polishing.

The bottom face of the optical device 11N coincides with the boundary 12C, and the optical material 18G is filled in the holes 14M and 15M. In Fig. 13, a convex lens is formed by the optical material 18G of the hole 15M.

Note that the optical device 11N may be made thinner to the desired thickness by polishing the upper face of the optical device 11N.

[0042]

Figure 14 is an explanatory view of a metallic mold pin.

Figure 14(A) shows the metallic mold pin 5 used in the metallic mold 9 of Fig. 1, while Fig. 14(B) shows a comparison use metallic mold pin 6 compared with the related metallic mold pin 5.

The metallic mold pin 5 of Fig. 14(A) has a head 5H and a projection 5A projecting out from the head 5H in the vertical direction. The projection 5A has a pole 5P, taper 5T, and front end 5M.

On the other hand, the metallic mold pin 6 of Fig. 14(B) has a head 5H and a projection 6A projecting out from the head 5H in the vertical direction. The pr jection 6A has a pole 6P and a front end 6M.

[0043]

Figure 15 is an explanatory view comparing the shapes of the projections 5A and 6A of the metallic mold pins 5 and 6 of Figs. 14(A) and 14(B) and draws part of the projections 5A and 6A overlappingly.

The front end 5M of the projection 5A of the metallic mold pin 5 has the same shape as the front end 6M of the projection 6A of the metallic mold pin 6, and its maximum diameter is 1a.

The diameter of the pole 5P of the projection 5A of the metallic mold pin 5 is a constant value (1a + 1b x 2), while the diameter of the pole 6P of the projection 6A of the metallic mold pin 6 is the constant value (1a).

The projection 5A of the metallic mold pin 5 is thicker than the projection 6A, so can improve the strength of the projection in comparison with the metallic mold pin 6. At the same time, the machining of the front end of the projection is easy.

[0044]

In the embodiment, the metallic mold 9 uses two metallic mold pins 4 and 5, but a further larger number of metallic mold pins can be used as well. By arranging a plurality of metallic mold pins having sharp front ends (for example arranging them in a matrix form), it is possible t form a micro-lens array.

[0045]

Note that the optical material to be injected into the cavity 1 may be made a molten glass made of silicon oxide, while the optical material 18G may be tantalum oxide, niobium oxide, titanium oxide, gallium phosphate (gallium phosphorus), gallium nitride, a compound of tantalum, titanium, and oxygen, and so on.

[0046]

By making the refractive index of the optical material 18G larger than the refractive index of the optical material of the base material 12, the function of a convex lens can be imparted to the holes 14M and 15M and the base material 12A adjacent to the related holes 14M and 15M.

By making the refractive index of the optical material 18G smaller than the refractive index of the optical material of the base material 12, the function of a concave lens can be imparted to the holes 14M and 15M and the base material 12A adjacent to the related holes 14M and 15M.

[0047]

The metallic mold pins 4 and 5 may be provided at an upper side of the metallic mold 9 or may be provided at a lower side.

Also, the embodiment is an illustration of the present invention. The present invention is not limited

t the embodiment.

[0048]

[Effect of the Invention]

As explained above, according to the present invention, a method of production of an optical device capable of producing an optical device having a small sized lens, a metallic mold for production of an optical device useable in this method of production of an optical device, and an optical device which can be obtained by the related method of production of an optical device can be provided.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

A schematic view of the configuration of an embodiment of a metallic mold for production of an optical device according to the present invention.

[Fig. 2]

A schematic partially enlarged view of a projection of a metallic mold pin in Fig. 1.

[Fig. 3]

An explanatory view of a molded article produced by the metallic mold for production of the optical device of Fig. 1.

[Fig. 4]

An enlarged view of a concavity of a molded article

of Fig. 3 and the area around it.

[Fig. 5]

A schematic view of the configuration of an optical device according to the present invention.

[Fig. 6]

An enlarged view of a hole of the optical device of Fig. 5 and the area around it.

[Fig. 7]

An explanatory view of a state where a layer of an optical material is laminated on a bottom face of the molded article of Fig. 3.

[Fig. 8]

An enlarged view of the concavity of the molded article of Fig. 7 and the area around it.

[Fig. 9]

An explanatory view of an optical device produced from the molded article of Fig. 7.

[Fig. 10]

An enlarged view of the hole of the optical device of Fig. 9 and the area around it.

[Fig. 11]

A view of the configuration of an optical device obtained by polishing the bottom face of the optical devic f Fig. 9 and Fig. 10.

[Fig. 12]

A view of the configuration of an optical device obtained by polishing the bottom face of the optical device of Fig. 11.

[Fig. 13]

An enlarged view of the hole of the optical device of Fig. 12.

[Fig. 14]

An explanatory view of a metallic mold pin.

[Fig. 15]

An explanatory view comparing shapes of projections of the metallic mold pins of Figs. 14(A) and 14(B).

[Description of References]

1... cavity, 1B... bottom face of cavity 1, 2... passageway, 4 to 6... metallic mold pins (pins), 4A to 6A... projections, 5H... head, 5M, 6M... front ends, 5P, 6P... poles, 5T... taper, 5Z, 15Z... axes, 9... production use metallic mold (metallic mold), 11, 11K... molded articles, 11K', 11K", 11N, 17... optical devices, 11B... bottom face, 12... base material, 12A... upper side base material, 12B, 12B', 12B"... lower side base materials, 12C... boundary, 14A, 14A 15A, 15A 184, 185... concavities, 15M, 15P, 15P 15T... holes, 18... layer, 18G... optical material, and 94, 95... through hol s.

DOCUMENT NAME DRAWINGS

Fig. 1

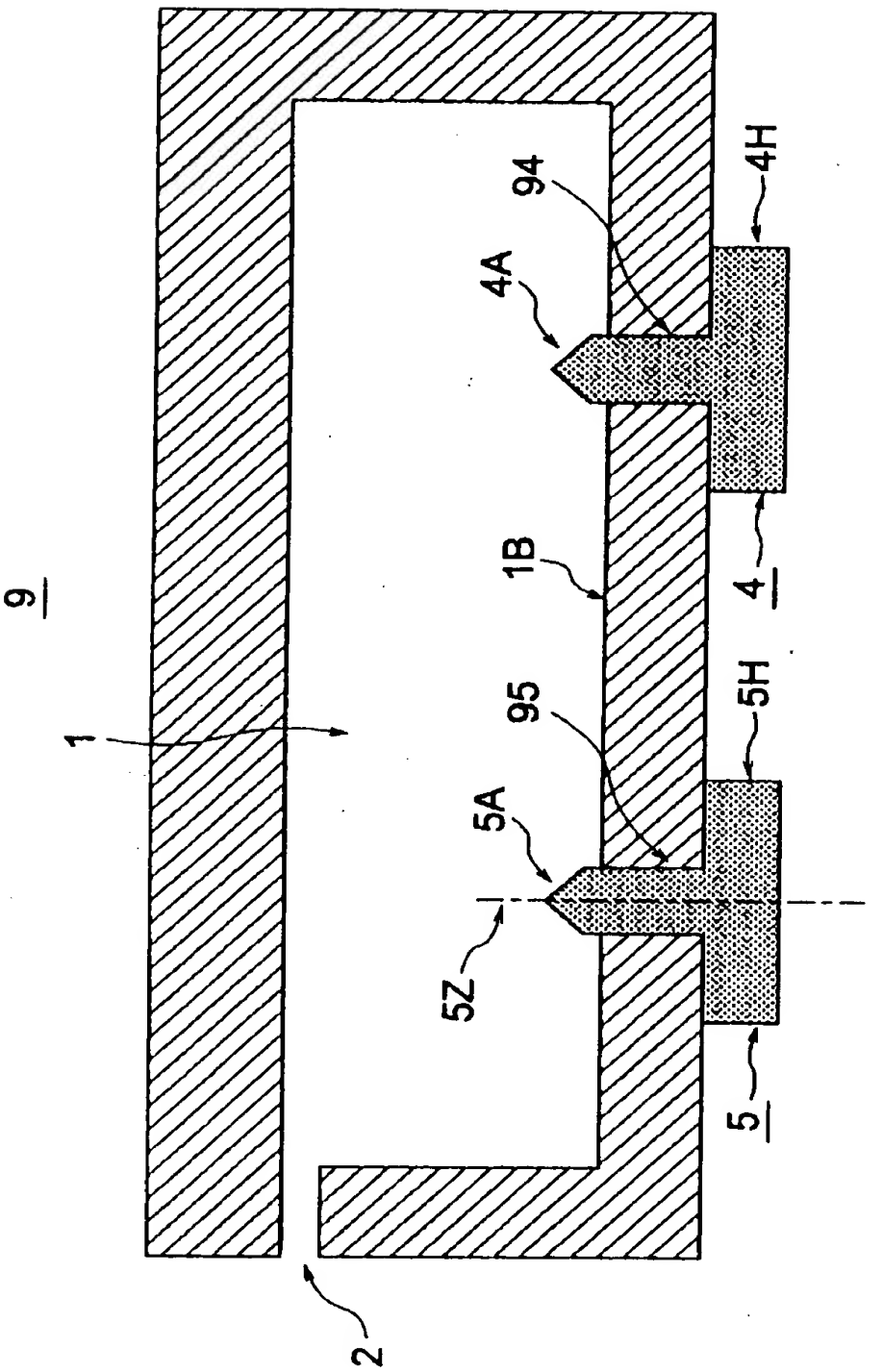


Fig. 2

5A

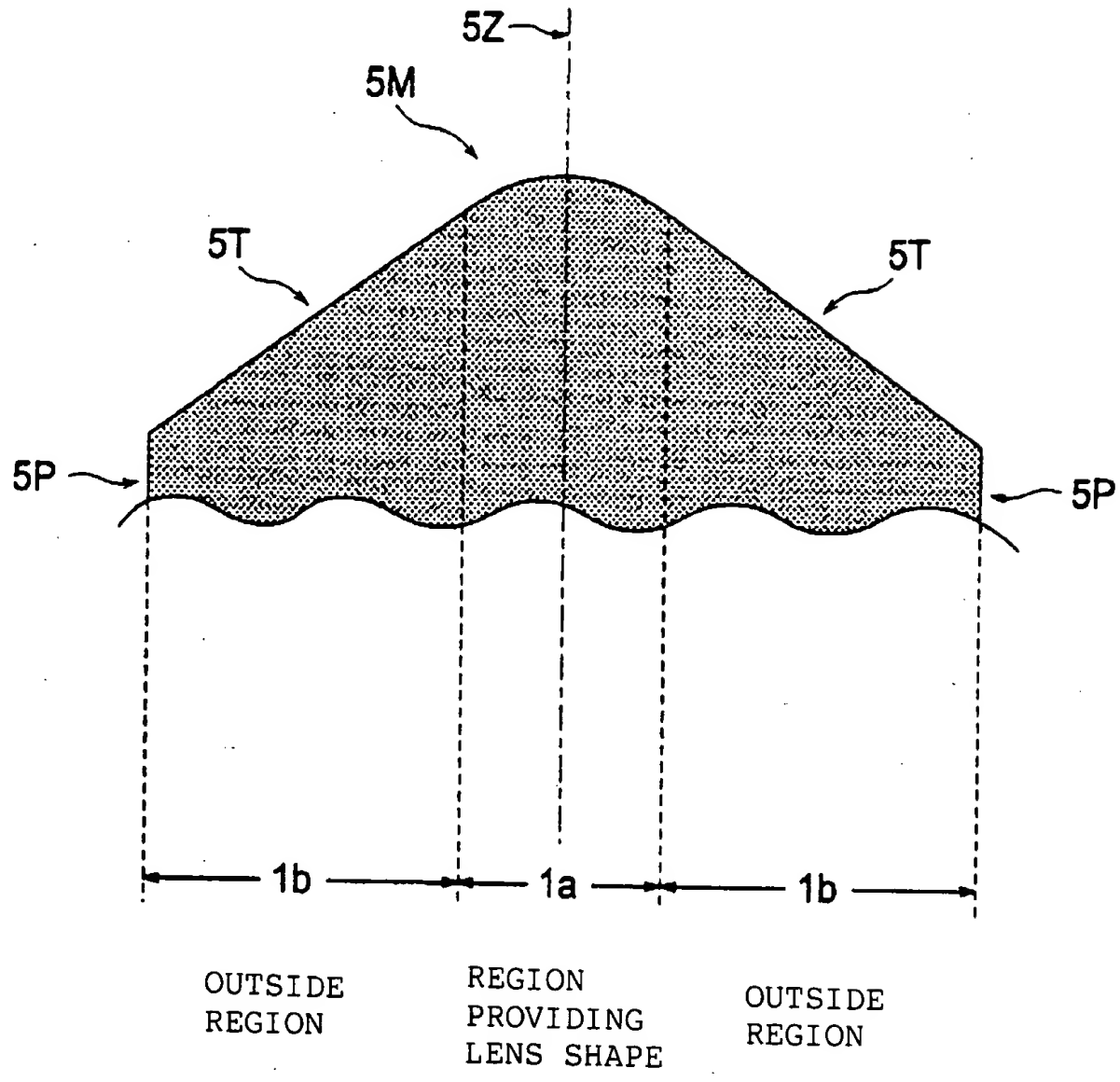
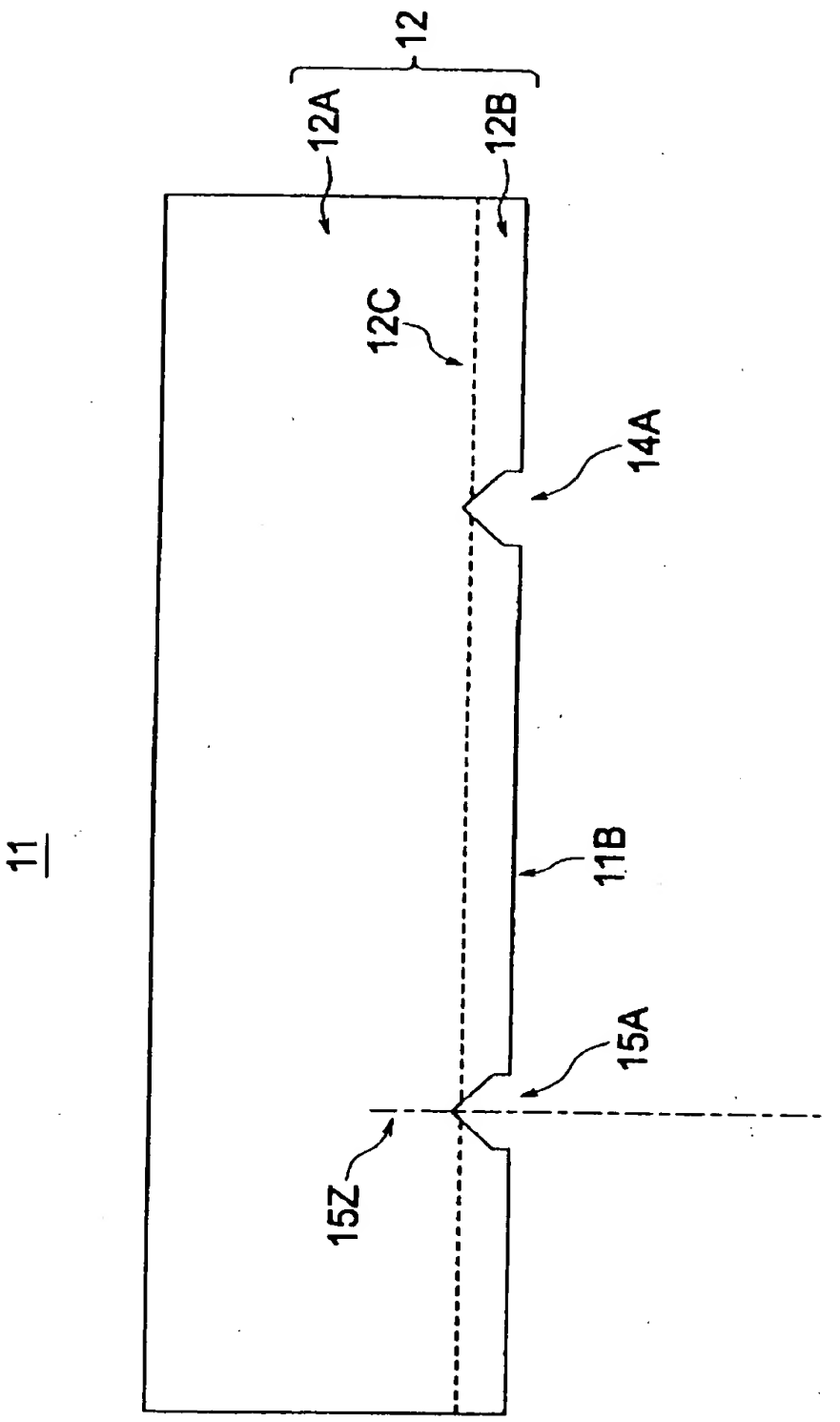


Fig. 3



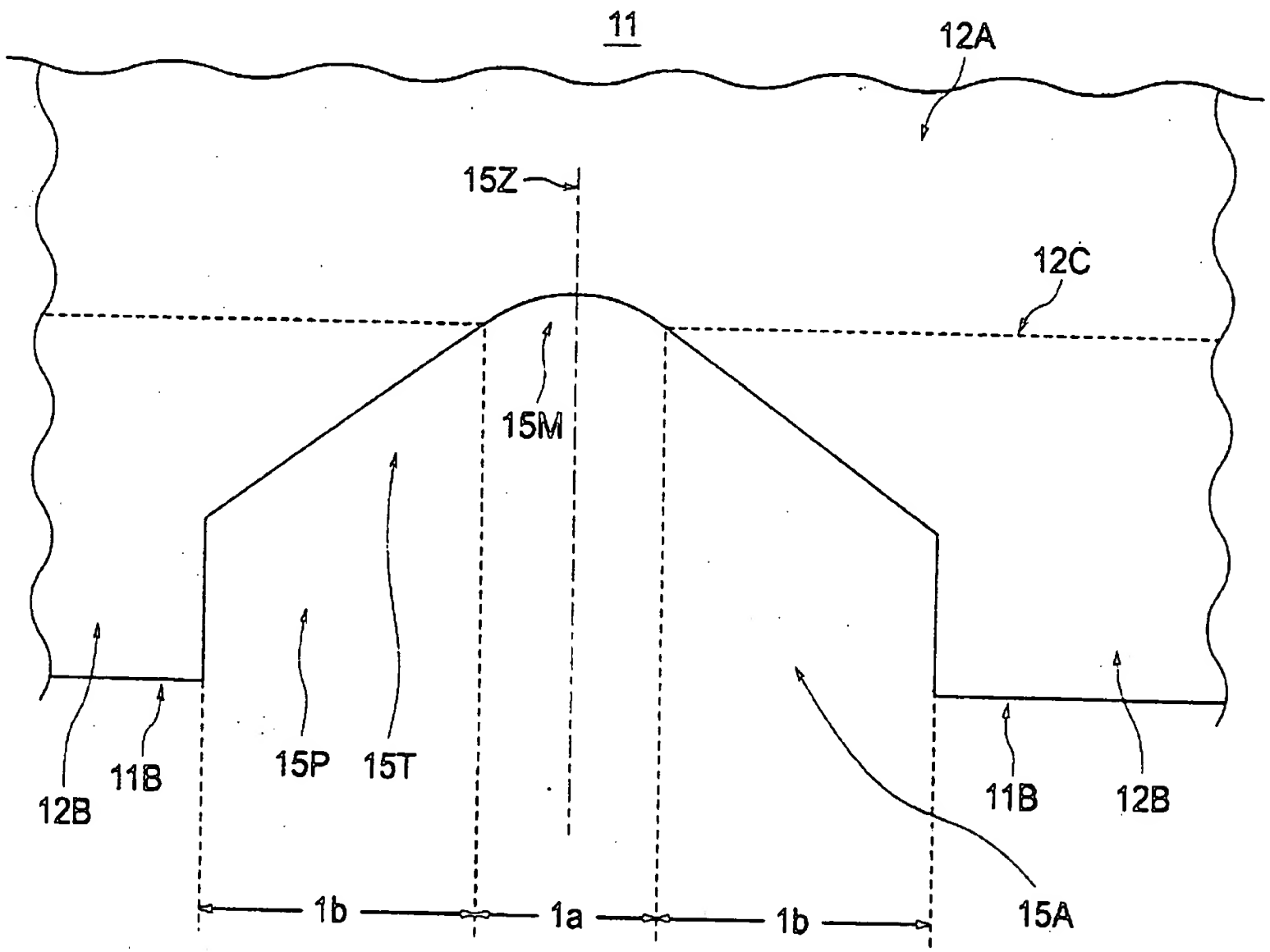


Fig. 4

Fig. 5

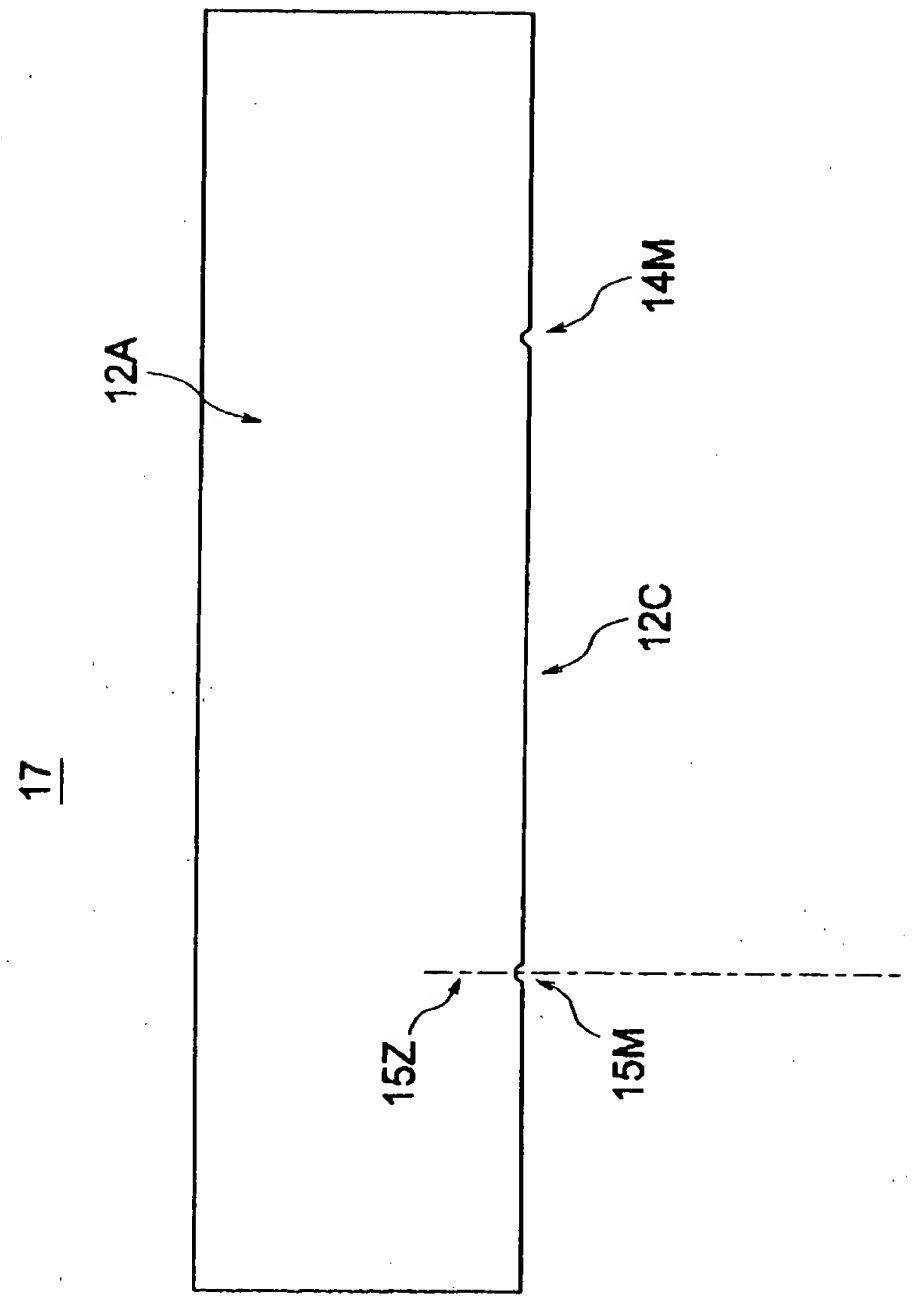


Fig. 6

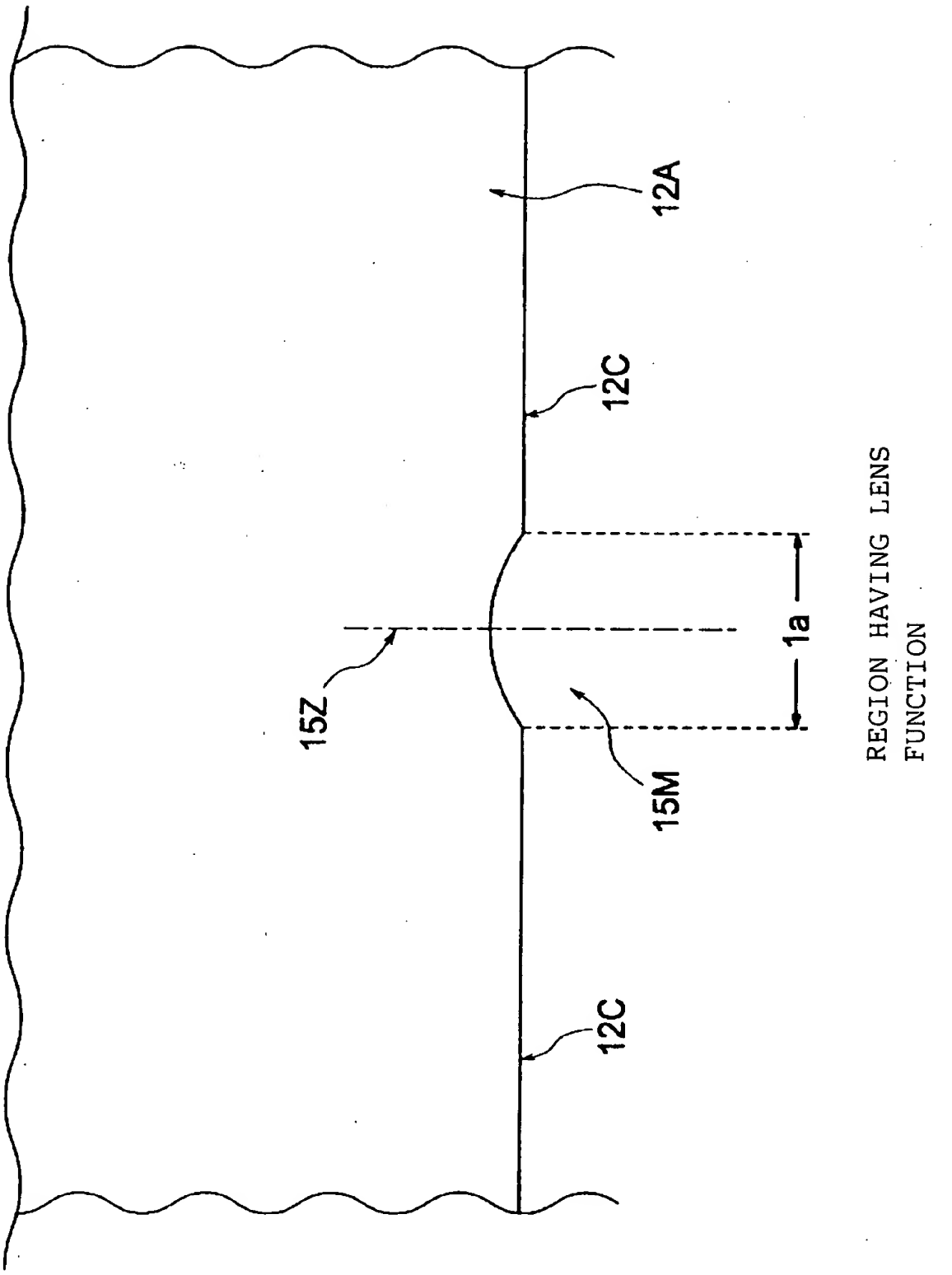
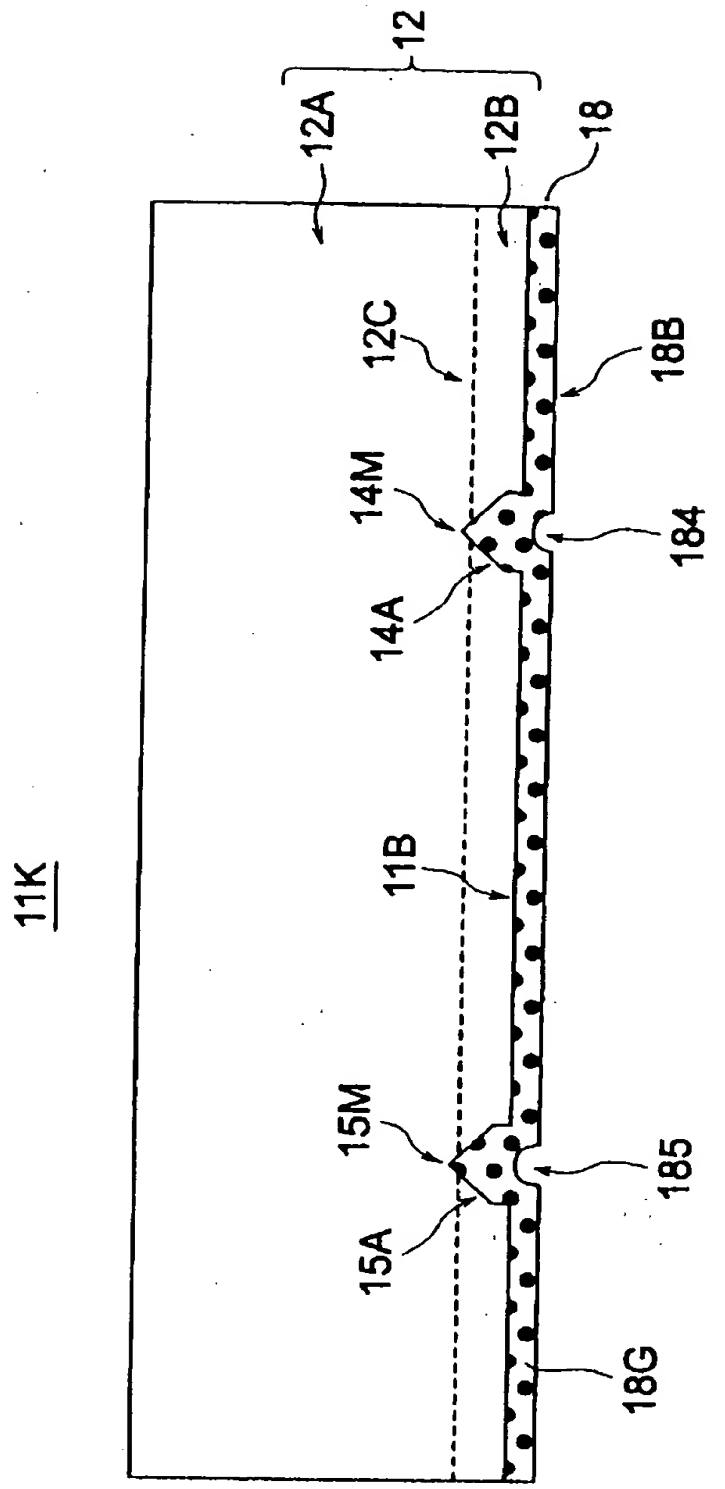


Fig. 7



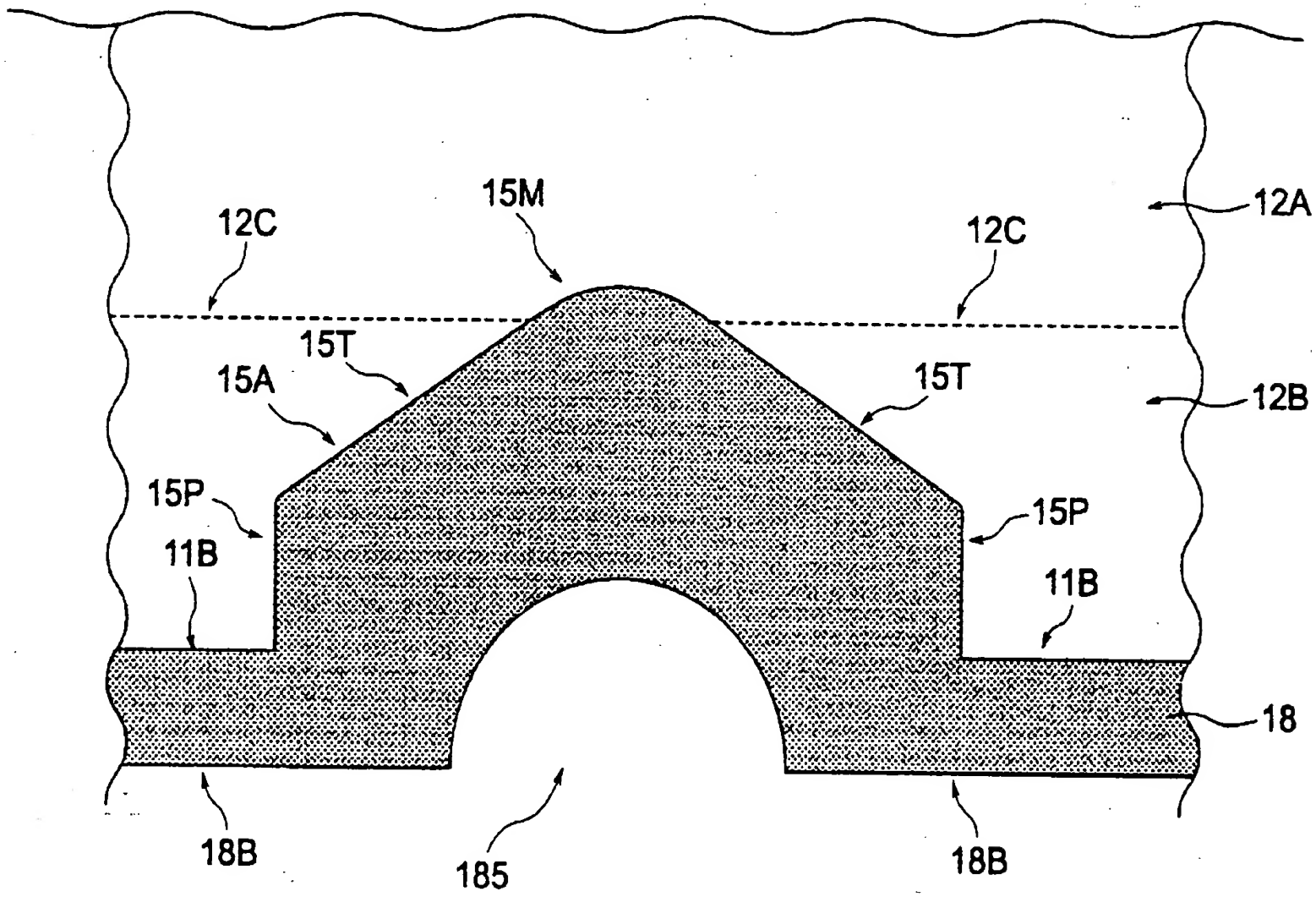


Fig. 8

Fig. 9

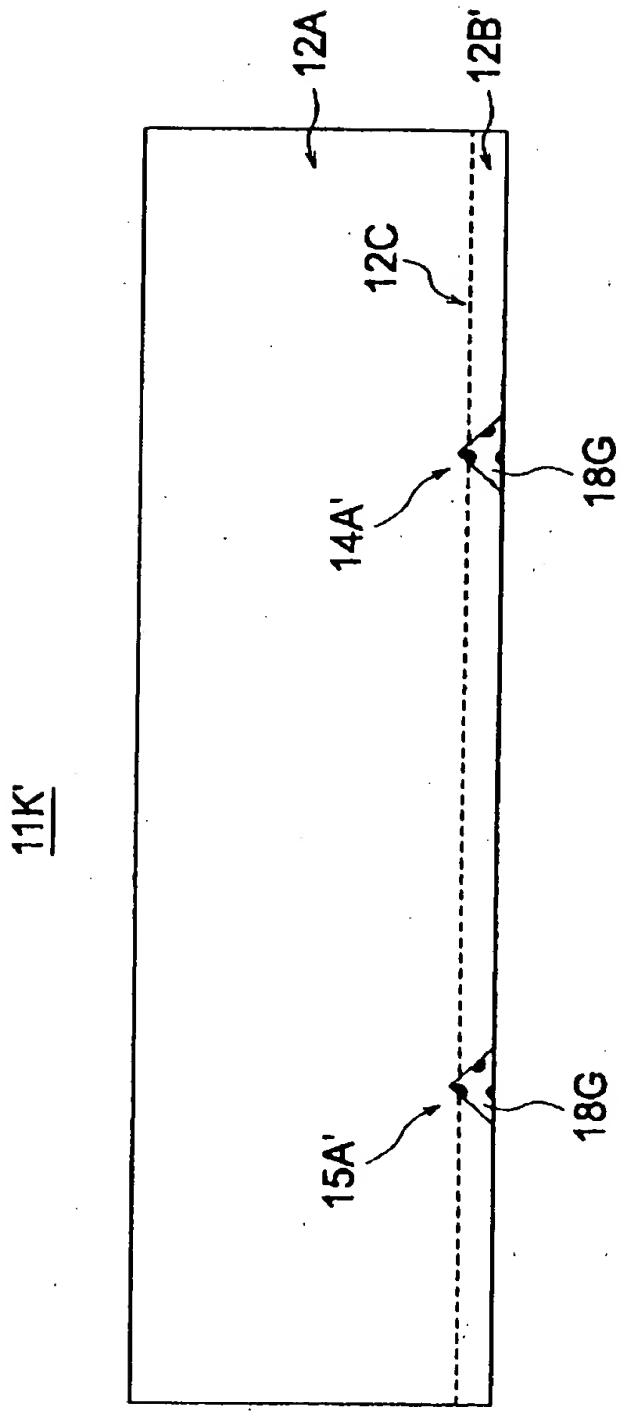


Fig. 10

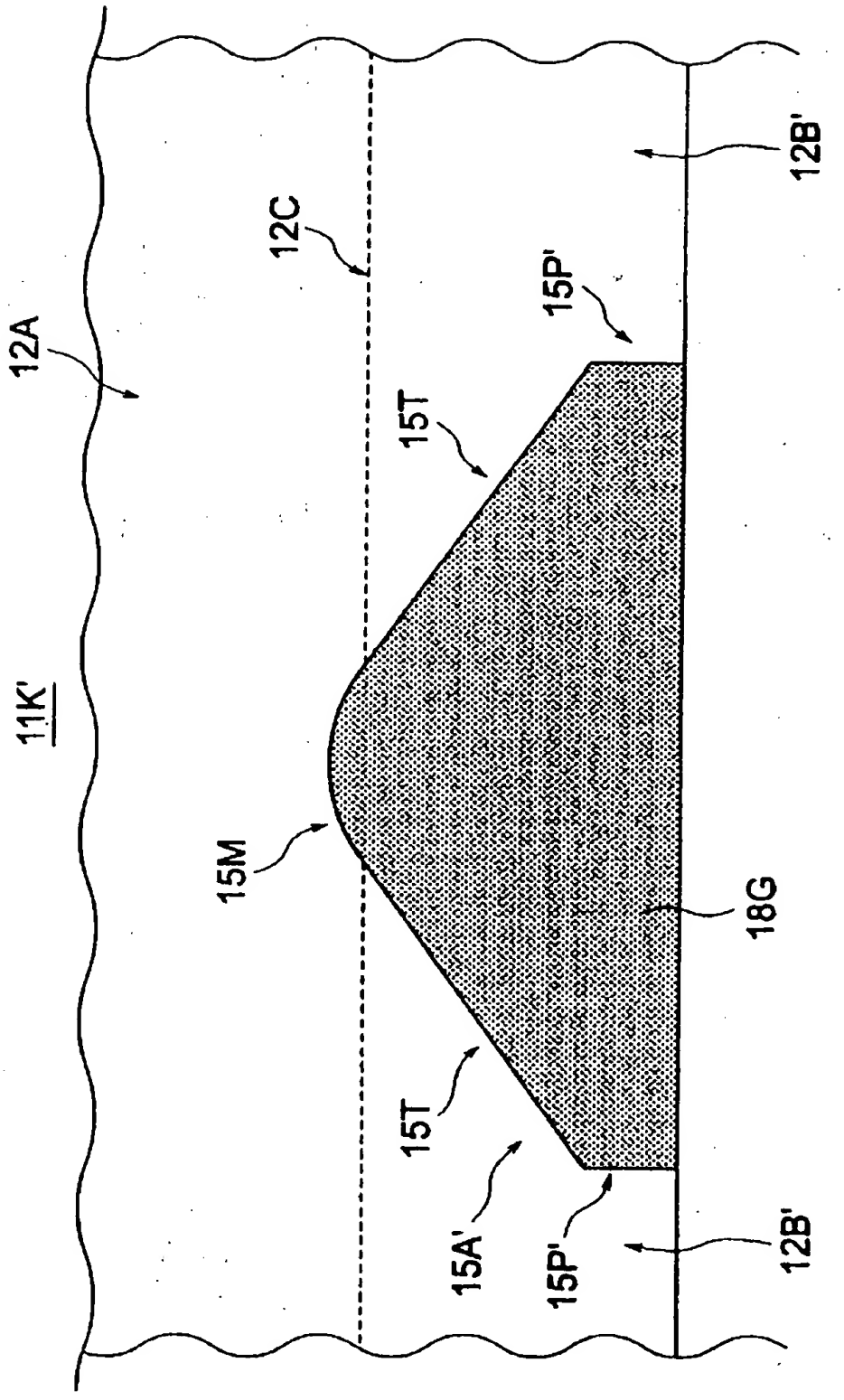


Fig. 11

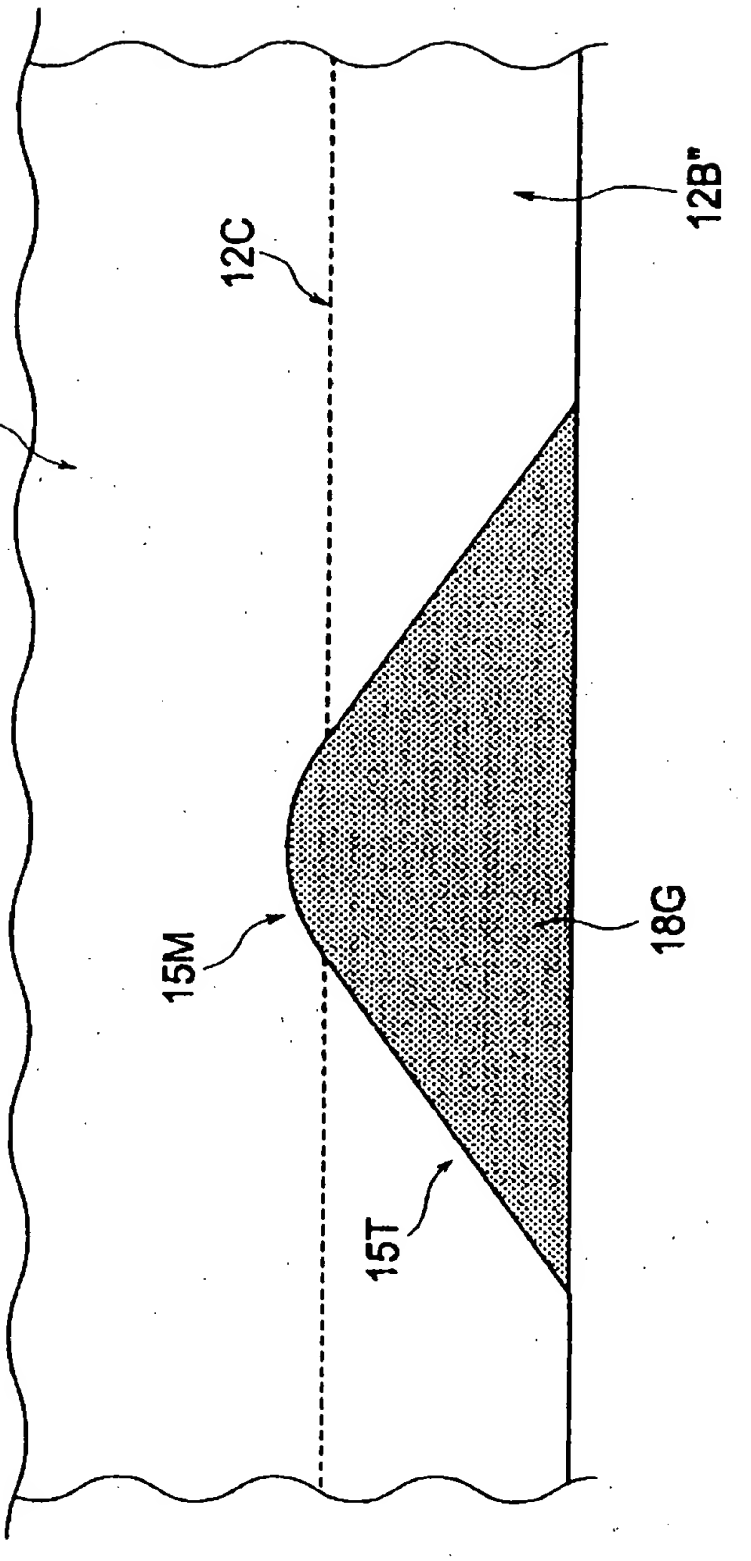


Fig. 12

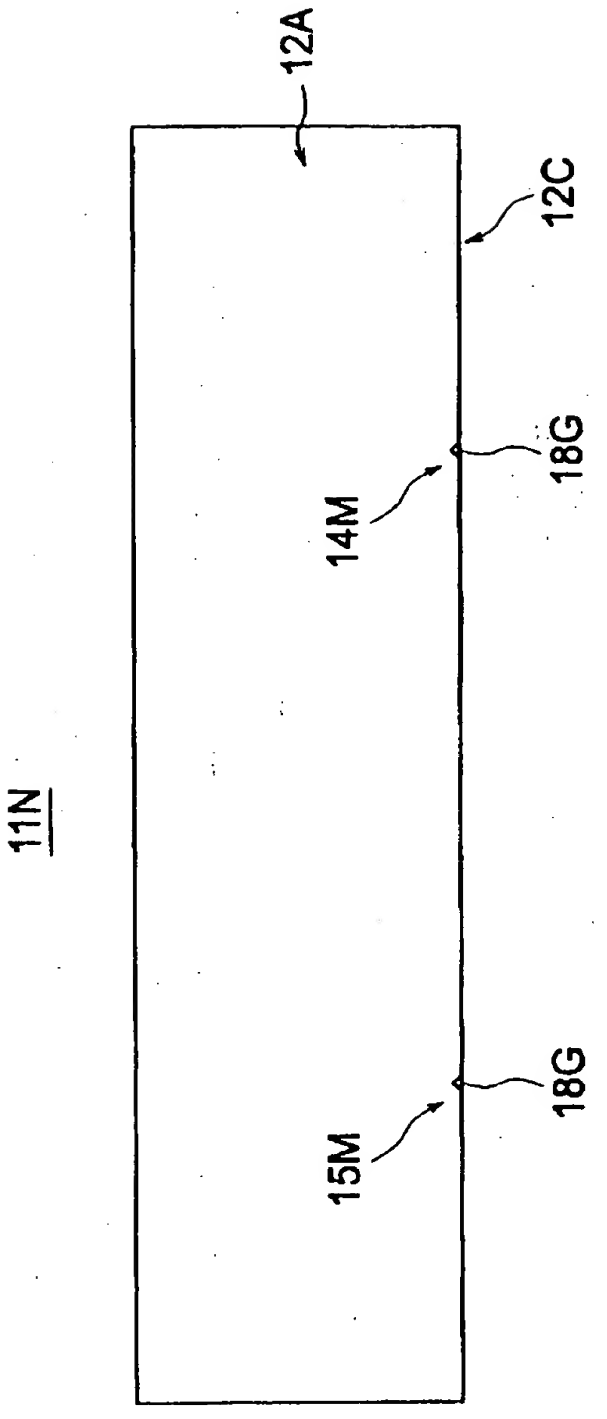


Fig. 13

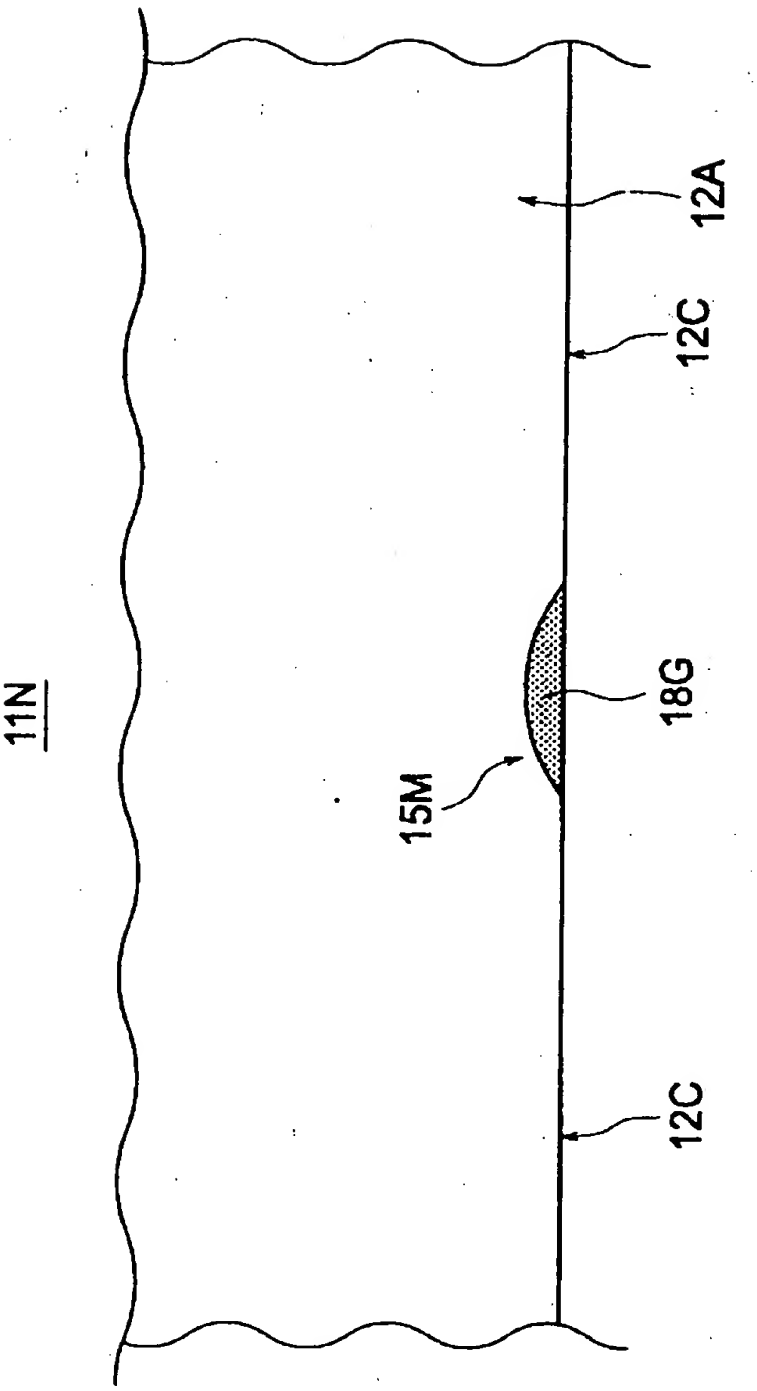
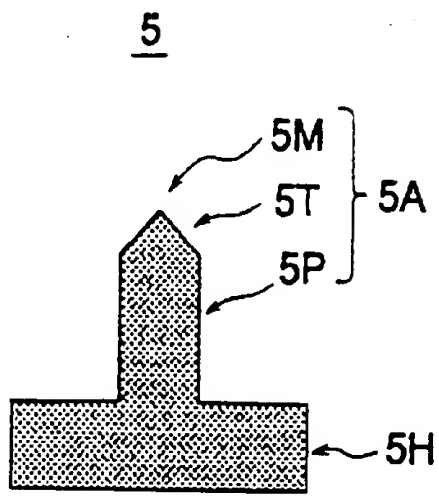


Fig. 14

(A)



(B)

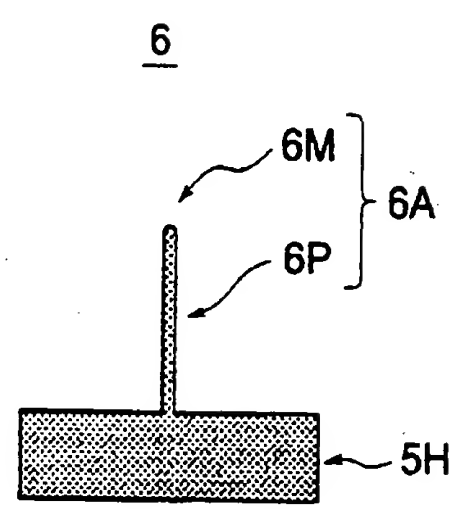
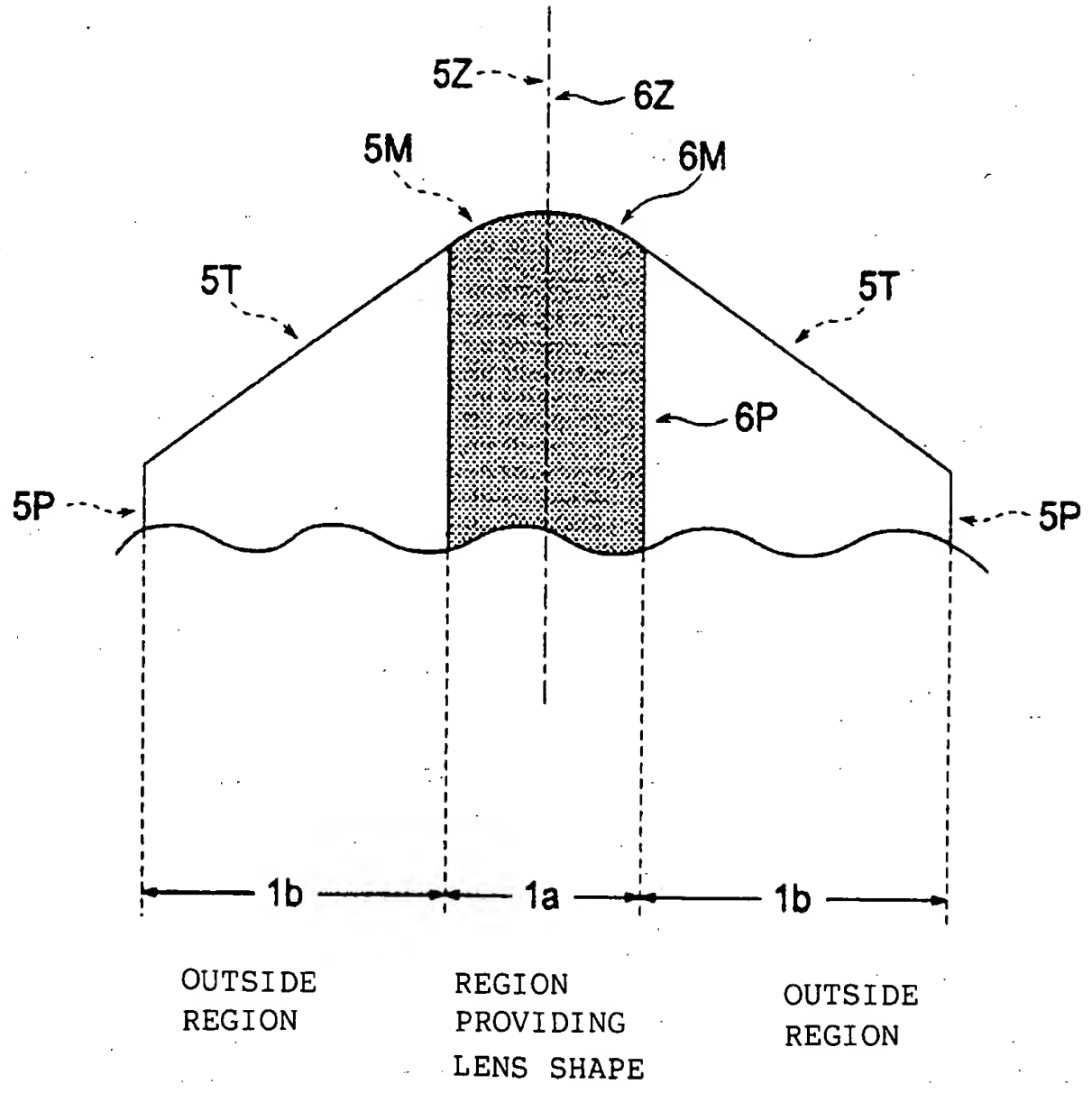


Fig. 15



[NAME OF DOCUMENT] Abstract

[ABSTRACT]

[PROBLEM] To provide a production use metallic mold useable for production of an optical device having a small sized lens.

[MEANS FOR SOLUTION] A production use metallic mold 9 of an optical device has a cavity 1 into which an optical material in a molten state or softened state is to be filled and pins 4 and 5 forming concavities in the optical material in the molten state or softened state in the cavity 1. The pins 4 and 5 project out into the cavity 1 while penetrating through a bottom wall of the cavity 1 from the outside. A front end of the concavity has a spherical or substantially spherical shape. By taking out a molded article and polishing or grinding the face where the concavity is formed, it is possible to produce an optical device having a small sized lens.

[SELECTED DRAWING] Fig. 1